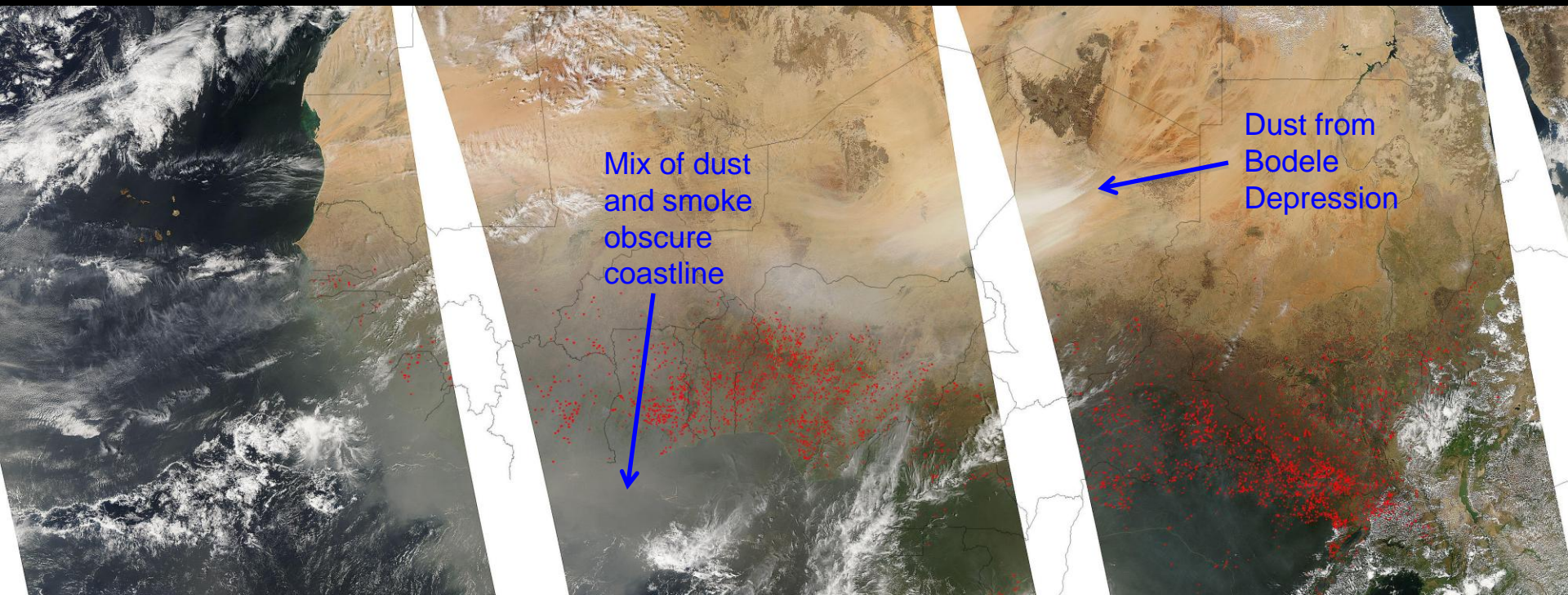


# Using Giovanni in Investigating the Links between Environmental Processes and Drought in Northern sub-Saharan Africa

**Charles Ichoku<sup>1</sup>**

**With Contributions from:** Charles Gatebe<sup>1,2</sup>, Jejung Lee<sup>3</sup>, Jun Wang<sup>4</sup>, John Bolten<sup>1</sup>, Fritz Policelli<sup>1</sup>, Eric Wilcox<sup>5</sup>, Jimmy Adegoke<sup>3</sup>, Shahid Habib<sup>1</sup>, Rakiya Babamaaji<sup>3</sup>, Churchill Okonkwo<sup>6</sup>, Luke Ellison<sup>1,7</sup>, Rajesh Poudyal<sup>1,7</sup>

1. NASA Goddard Space Flight Center, Greenbelt, MD
2. Universities Space Research Assoc, Boulder, CO
3. University of Missouri, Kansas City, MO
4. University of Nebraska, Lincoln, NE
5. Desert Research Institute, Reno, NV
6. CSIR, Pretoria, South Africa
7. Science Systems & Applications, Inc. (SSAI)



Aqua-MODIS image of January 17, 2007 (NASA EarthObservatory)

Presented at the Gregory G. Leptoukh Online Giovanni Workshop, NASA/GSFC, Greenbelt, MD, 25 – 27 September, 2012.

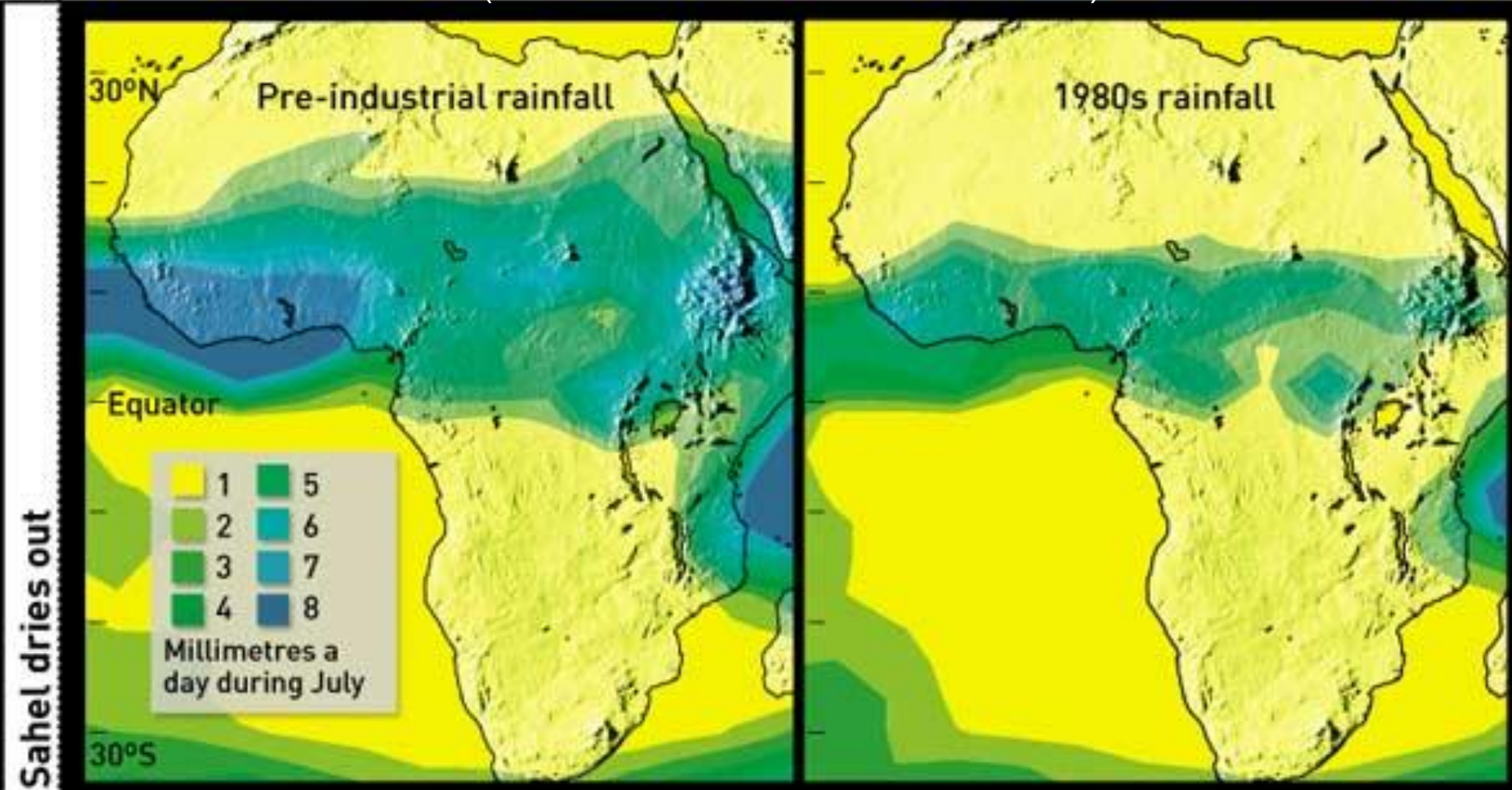
# Outline

- Sub-Saharan African Environment and Drought
- Hypothesis and Study Design
- Exploratory Data Analysis and Preliminary Findings
- Ongoing Detailed Analysis and Modeling Efforts
- Future Outlook



# African Droughts

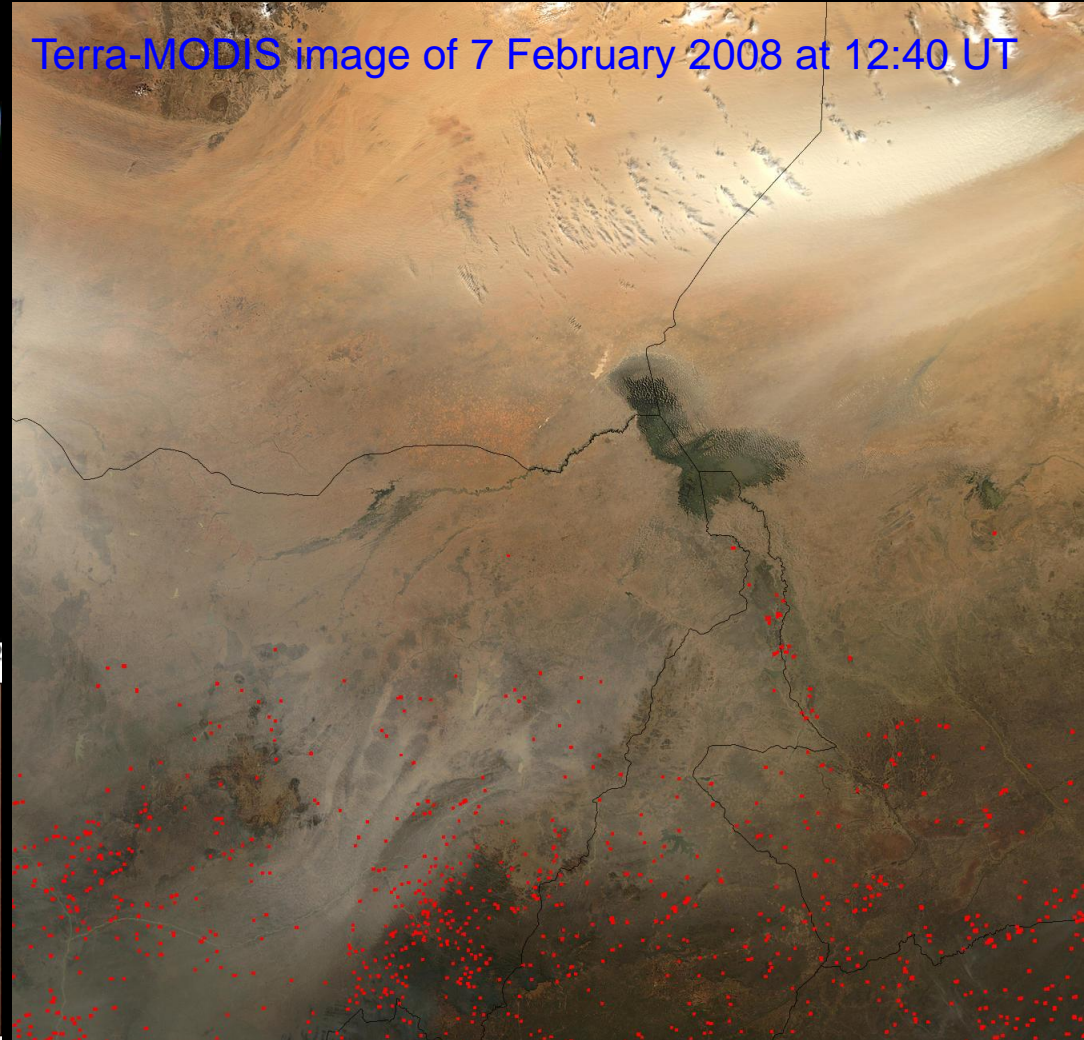
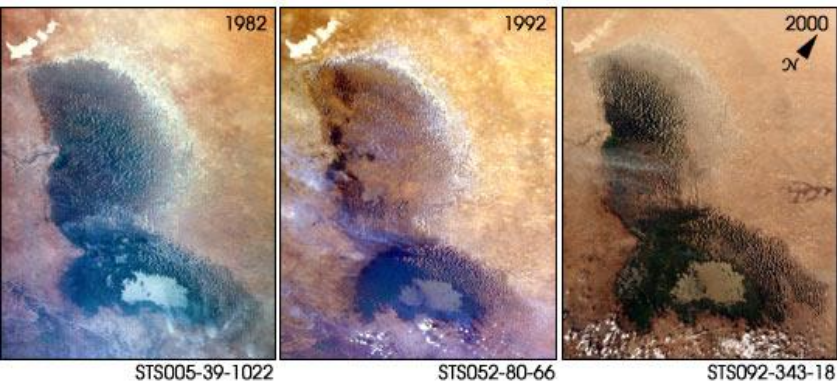
(New Scientist: 19:00 12 June 2002)



“Although the droughts have had climate experts scratching their heads, the impacts have been obvious. During the worst years, between 1972 and 1975, and 1984 and 1985, up to a million people starved to death.”



# Lake Chad: poster child of African Sahel Droughts



Fires → Bare Soil → Dust → Desertification



# Republic of Ghana



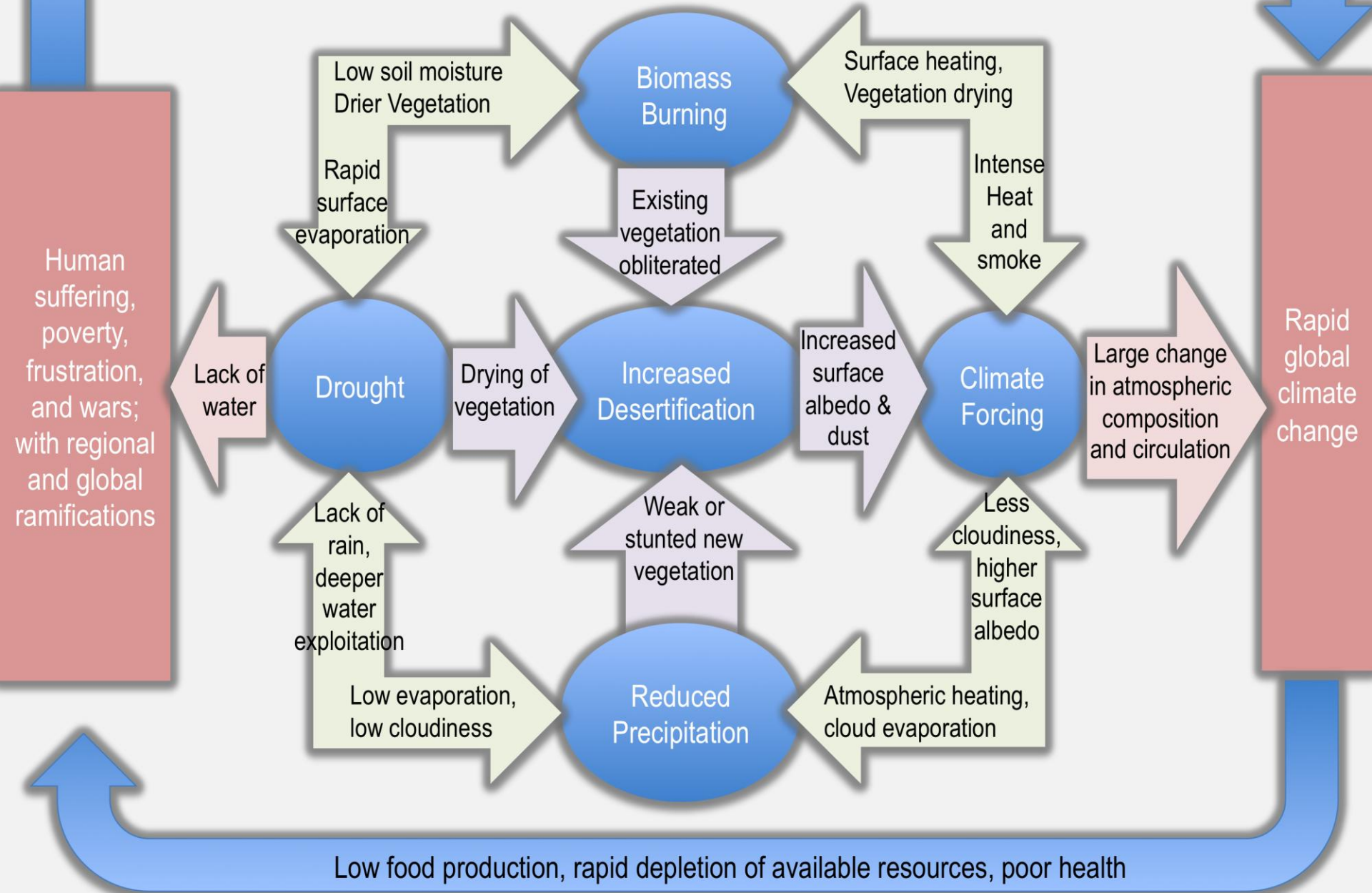
## Forest Reserves Under Pressure in Ghana



In the 1973 image the vegetation inside and outside the protected areas appears green and robust

In the 2002/2003 dramatic change is apparent; some of the northern reserves have been decimated and the northern edge of the forest zone has moved south

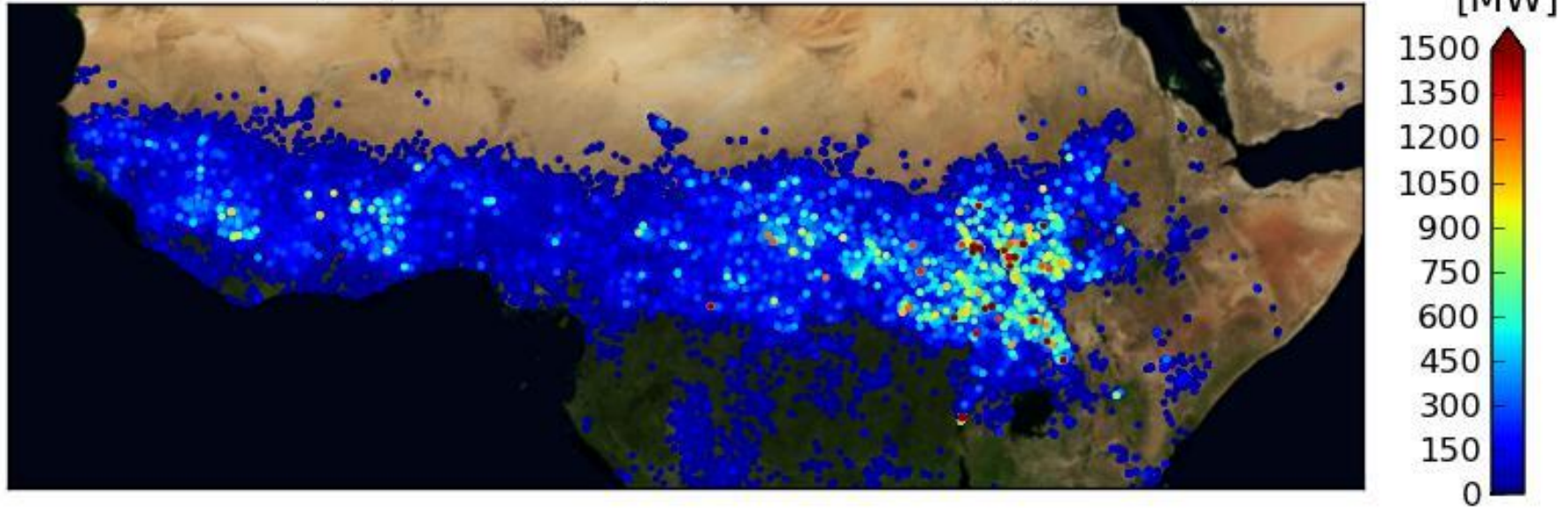
Lack of interest in global change issues, non participation in mitigation efforts, More biomass burning to survive.





# Biomass burning and water-cycle dynamics across Sub-Saharan Africa

MODIS Terra/Aqua Day/Night Fires during January 2012



## Science Questions:

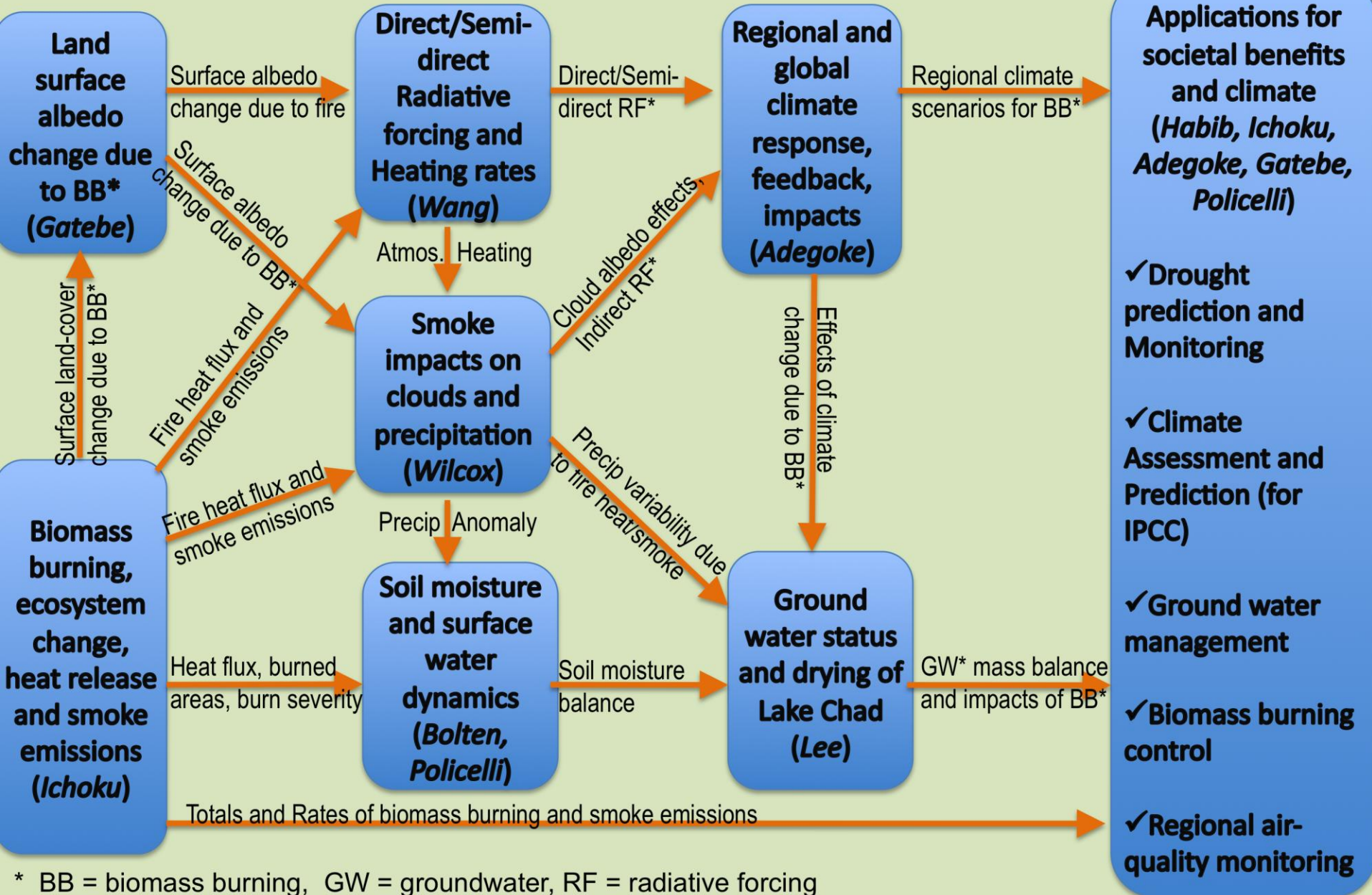
- To what extent does the seasonal biomass burning affect land-cover and ecosystem changes, smoke and dust emissions, atmospheric heating rates, and the consequent climate forcing in the NSSA region?
- How do these surface and atmospheric changes affect soil moisture content and retention, as well as rainfall variability and surface runoff?
- What are the links between the surface and atmospheric hydrologic processes induced or modified by biomass burning and the drying of Lake Chad, and what is the status and trend of the ground-water reserves in the greater Lake Chad basin and surrounding regions?
- What is the future of the regional climate and ecosystem balance, and how can the current degradation trend be mitigated to enhance societal benefits both in the present and the future?

## Observations and Analyses

## Process Modeling

## Integrated Modeling

## Results and applications





# Regional Data Analysis Based on Rough Ecosystem Segmentation



## Data Sources (NASA Giovanni)

NDVI => Terra/Aqua MODIS

Fire Radiative Power (FRP) => Terra/Aqua MODIS

Aerosol => Terra/Aqua-MODIS

Carbon Monoxide => Aqua-AIRS

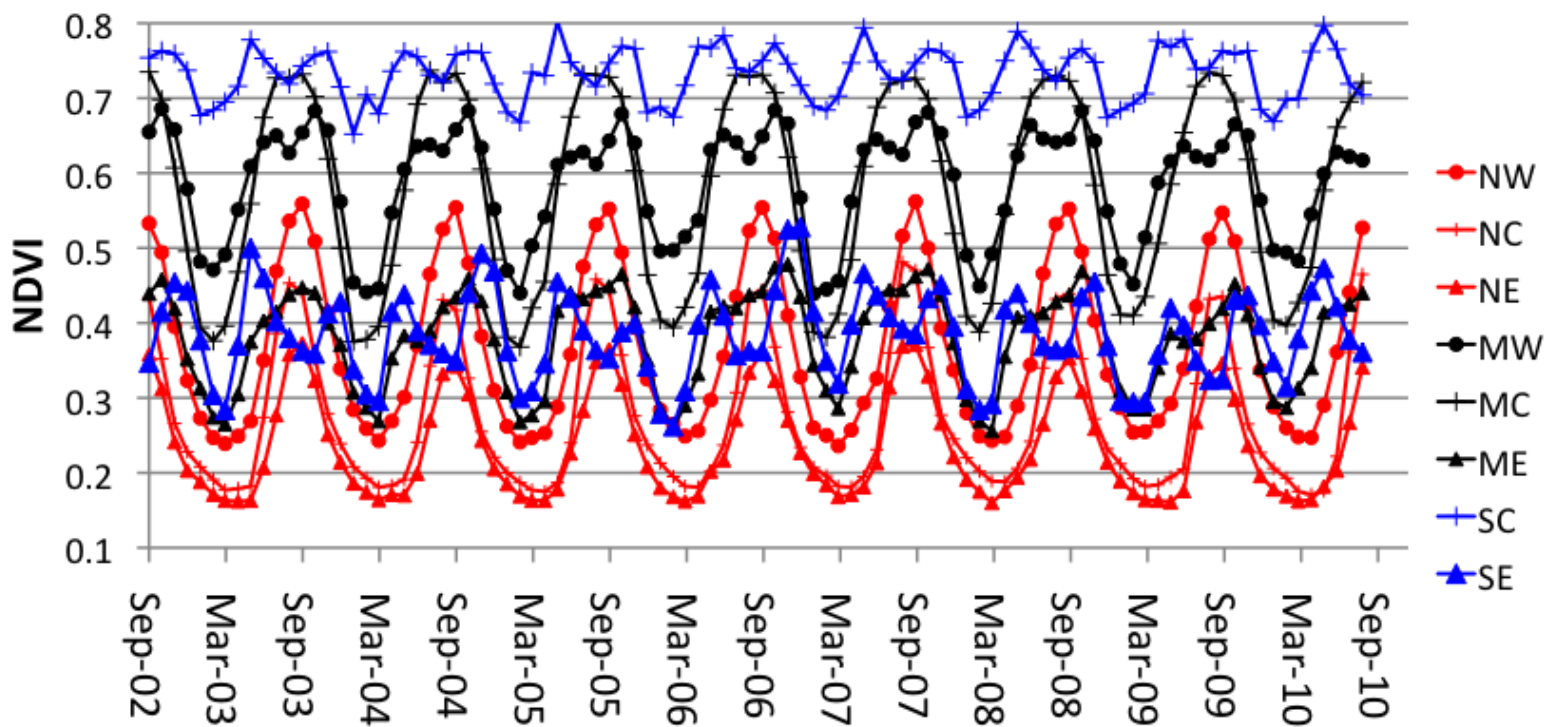
Precipitation => TRMM

Soil Moisture => Aqua AMSR-E

Surface Evaporation => MERRA

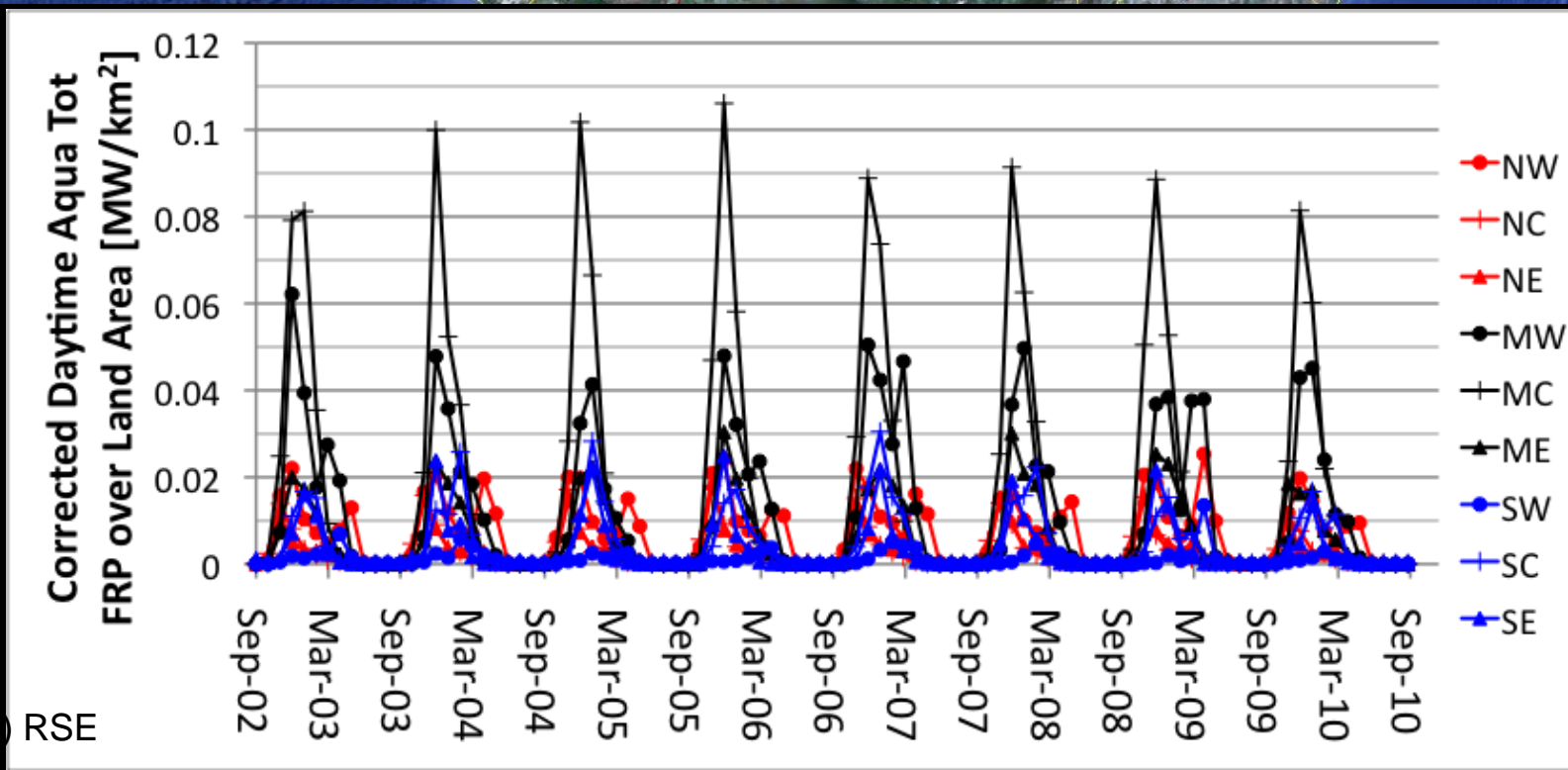


# Regional Data Analysis Based on Rough Ecosystem Segmentation





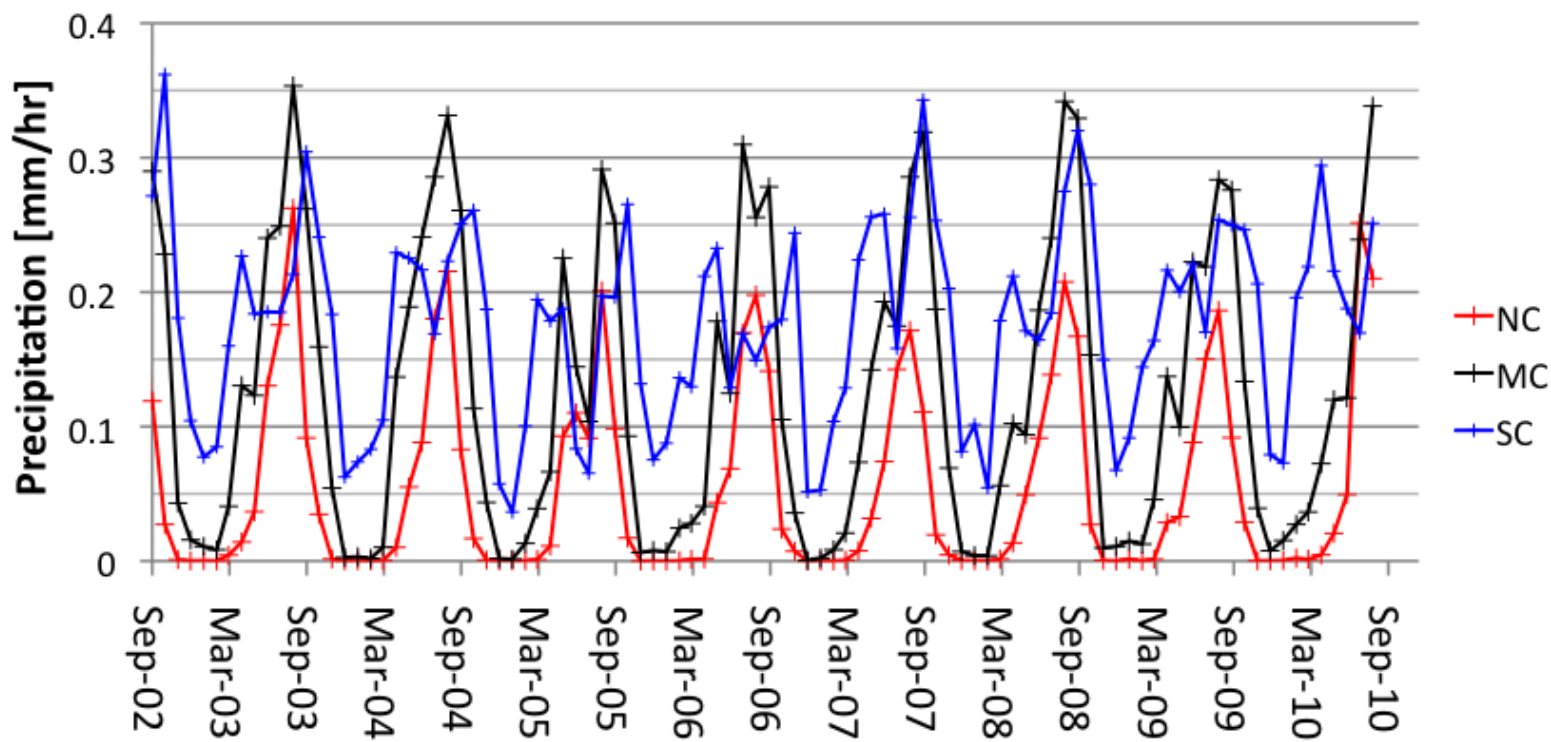
# Regional Data Analysis Based on Rough Ecosystem Segmentation



RSE

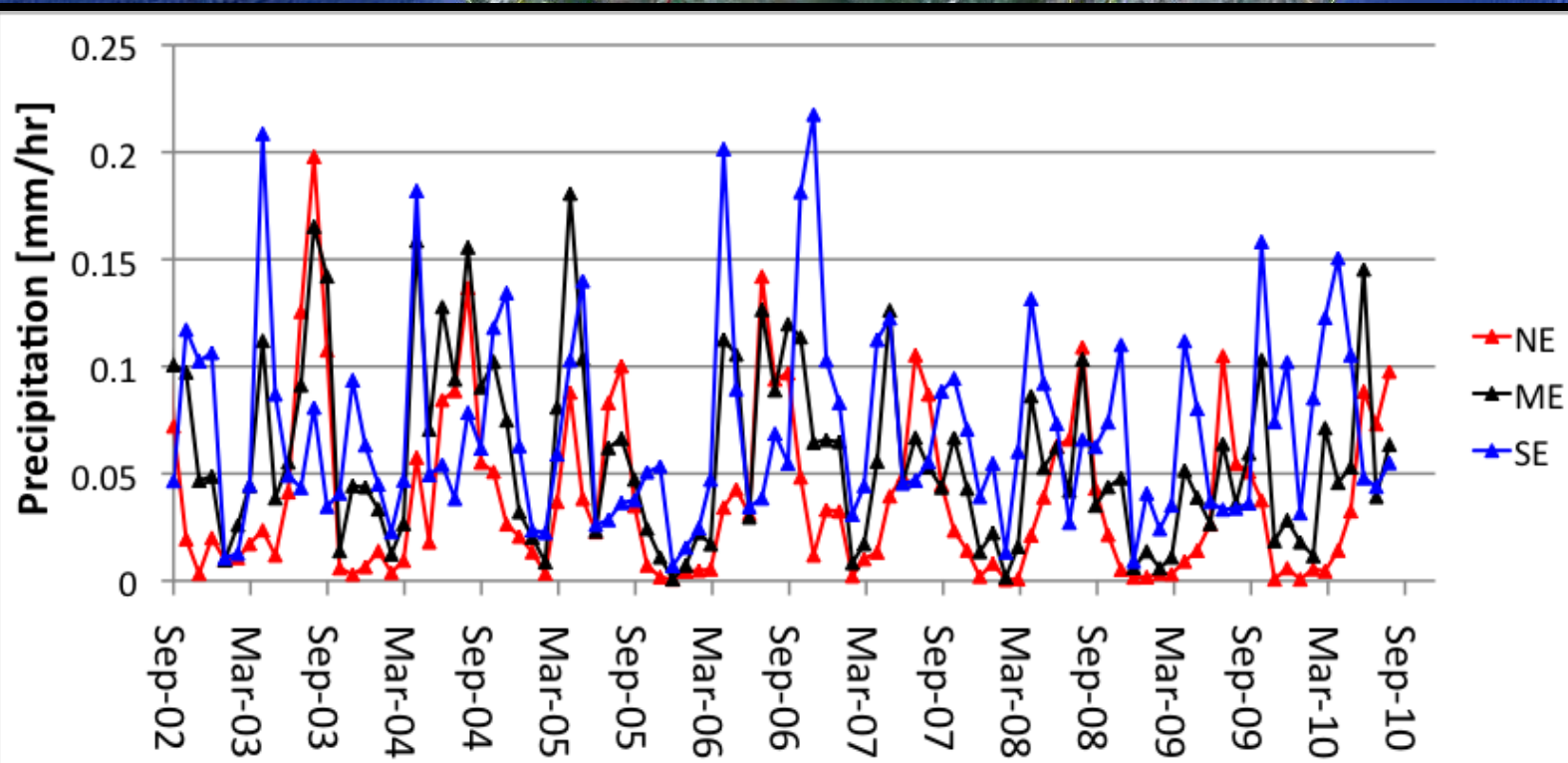


# Regional Data Analysis Based on Rough Ecosystem Segmentation



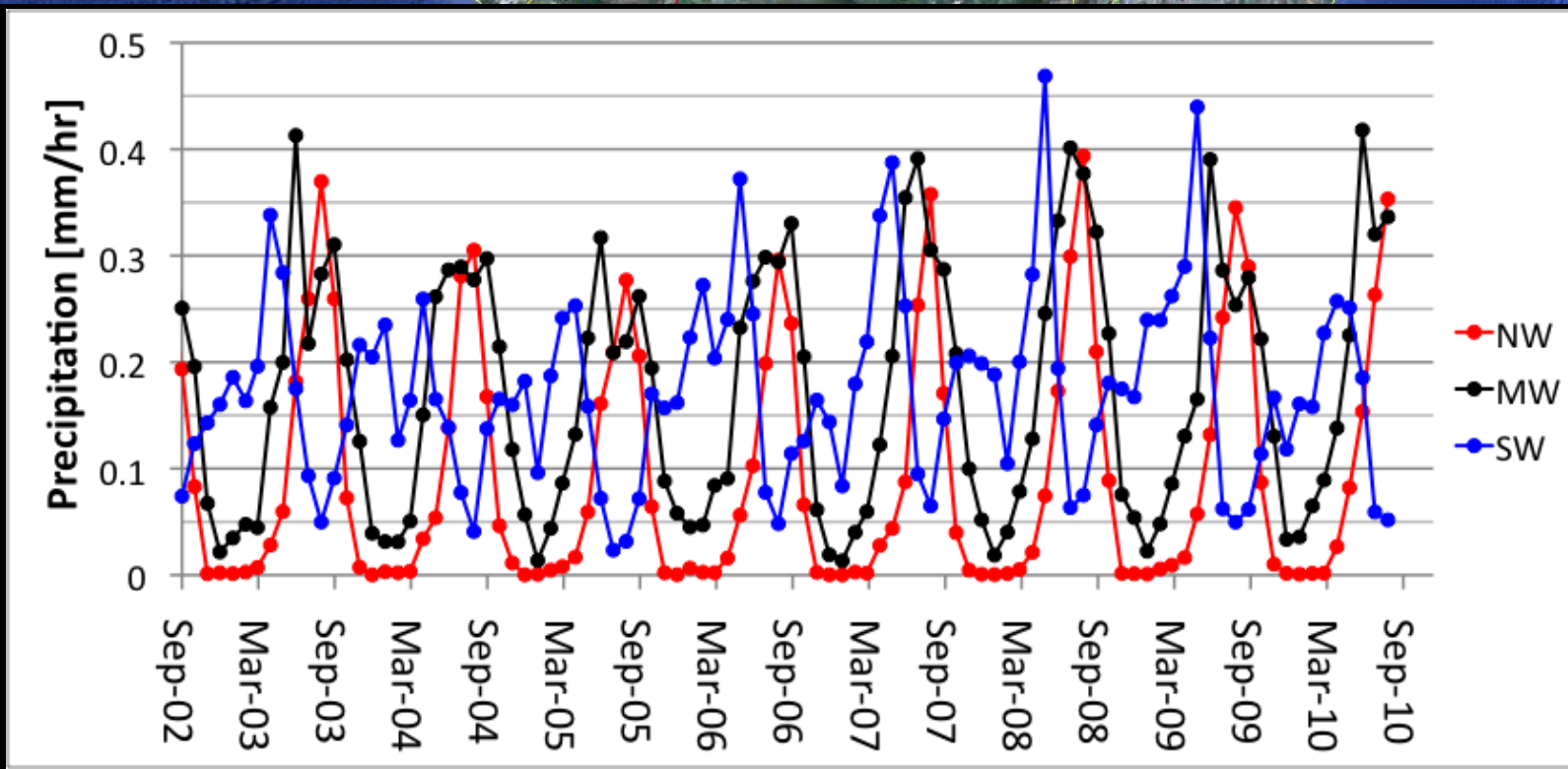


# Regional Data Analysis Based on Rough Ecosystem Segmentation



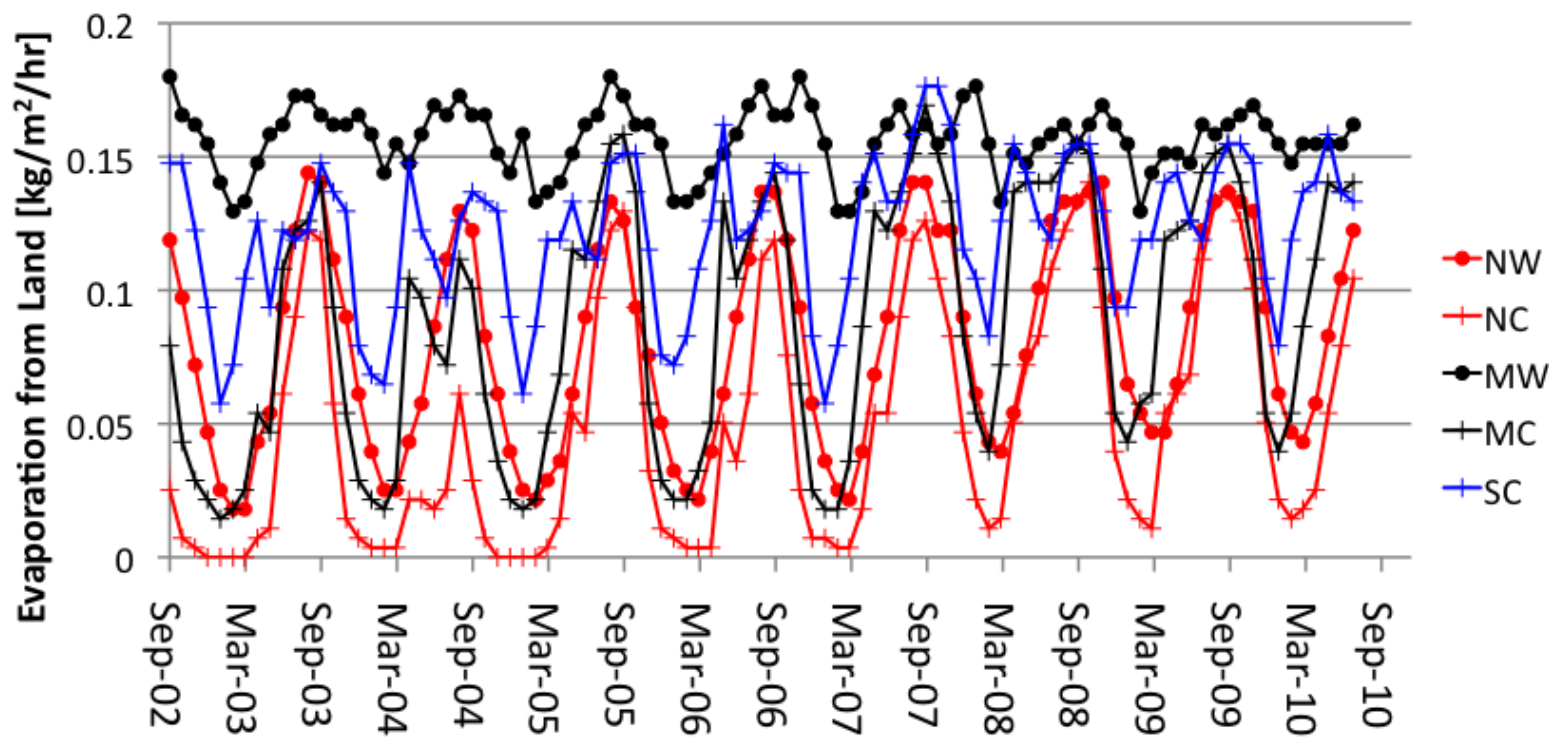


# Regional Data Analysis Based on Rough Ecosystem Segmentation





# Regional Data Analysis Based on Rough Ecosystem Segmentation



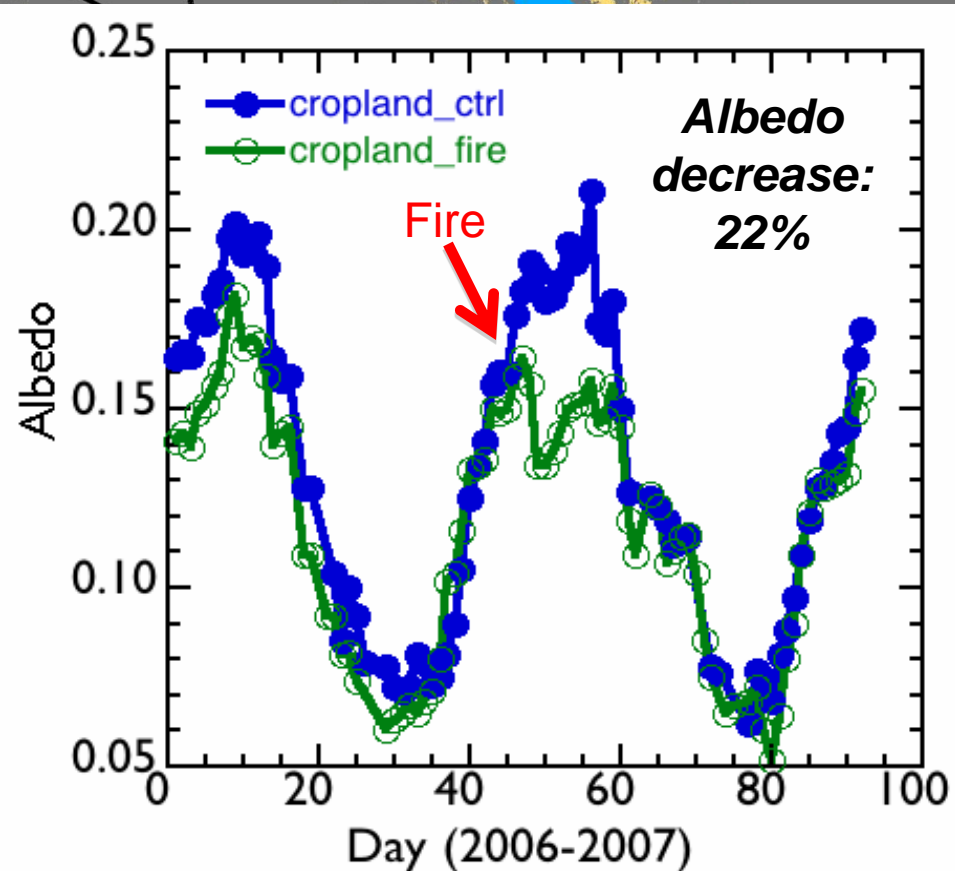
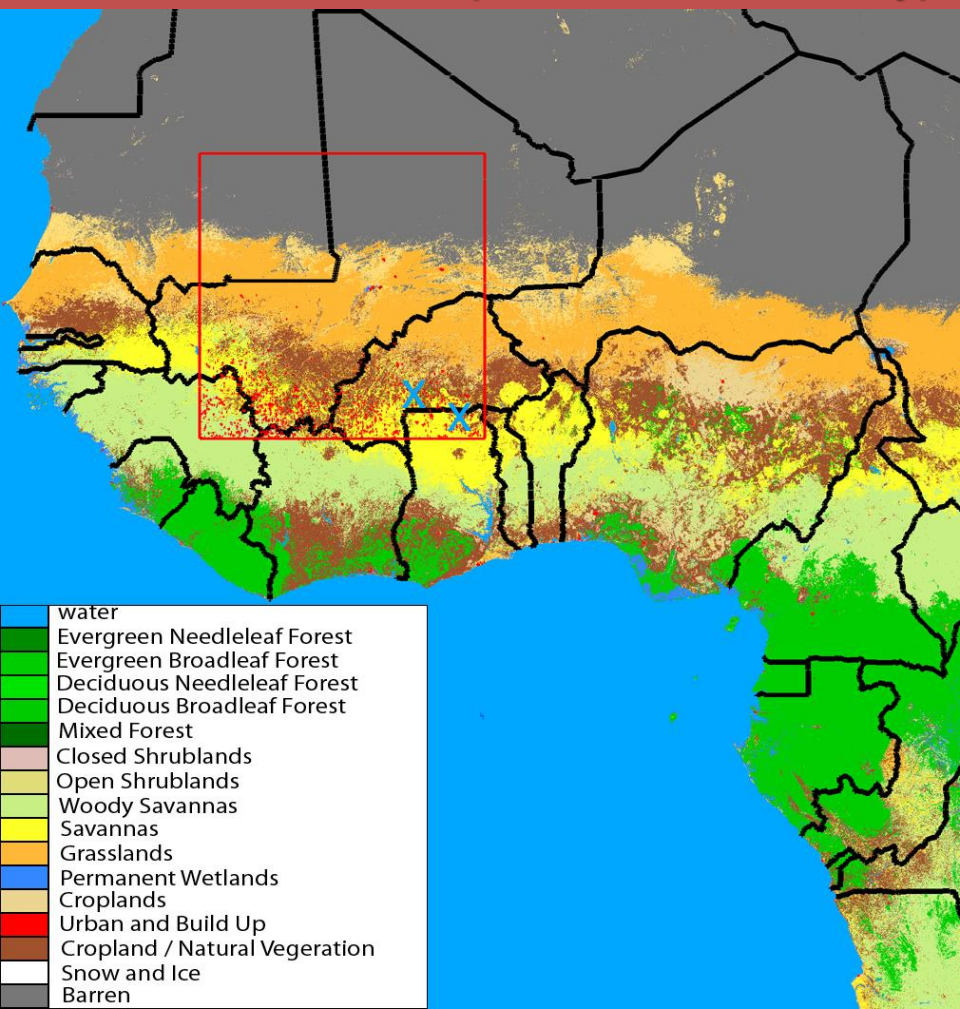
# Preliminary Findings

- Time Series Analysis of Regionally Aggregated Monthly Mean Satellite Measurements Shows That:
  - Fire activity appears to show a slightly decreasing trend in the Central and Eastern parts of the NSSA region starting in 2006/7.
  - This decrease in fire activity coincides with precipitation: increase in the Western, no change in the Central, and decrease in the Eastern parts of the NSSA.
  - Surface evaporation minima appear to have increased during the same period in the Western and Central parts.

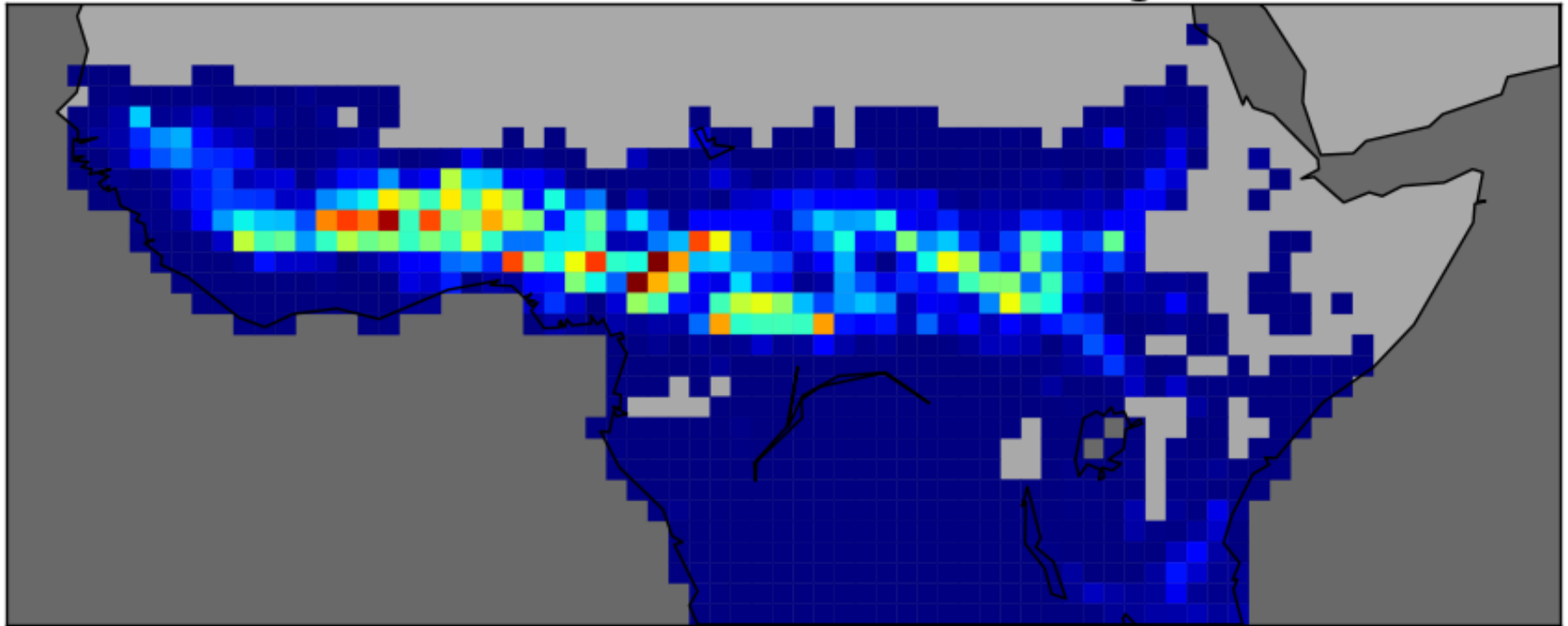


# Landcover type and Albedo Change

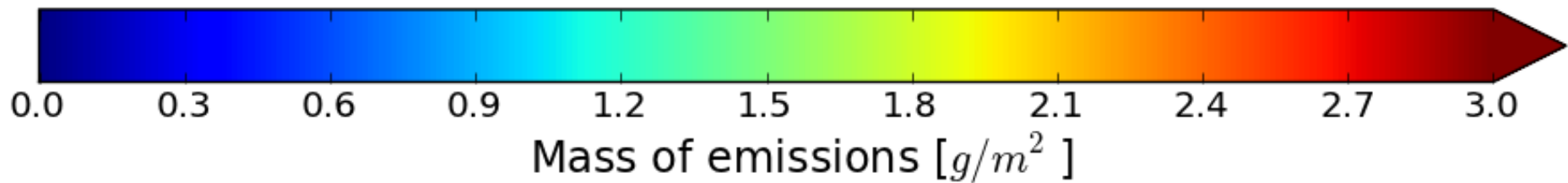
*Hypothesis: the impact of biomass burning on albedo will depend on landcover type*



# Smoke Particulate Emissions from fires in Northern Sub-Saharan Africa during Dec 2009

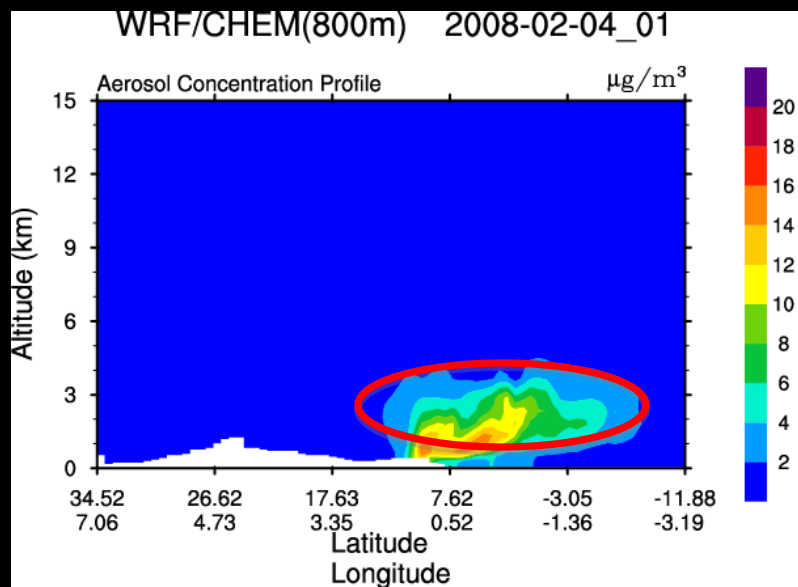
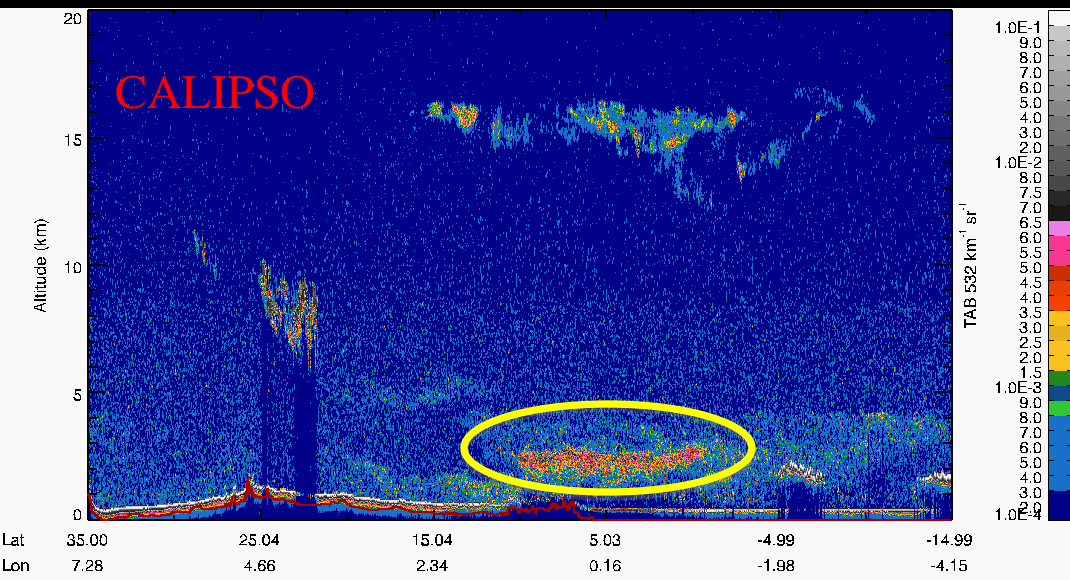
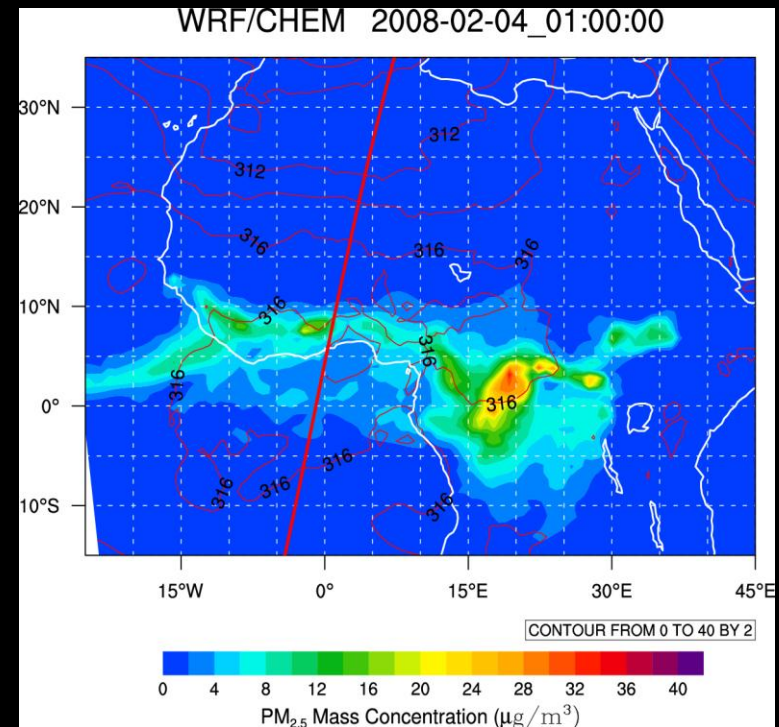
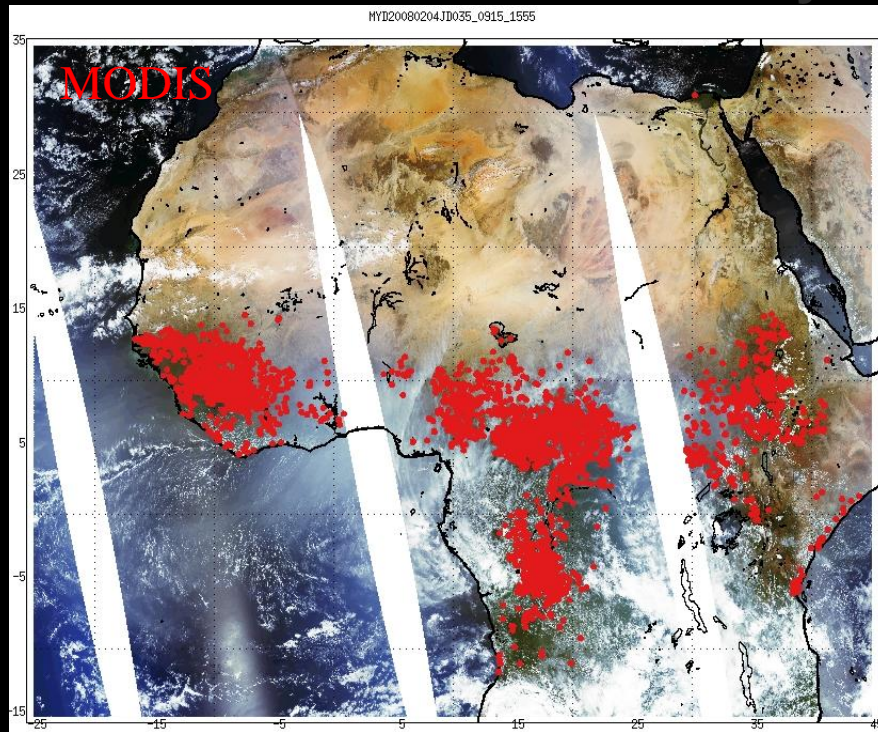


Total emissions: 2.98 Tg



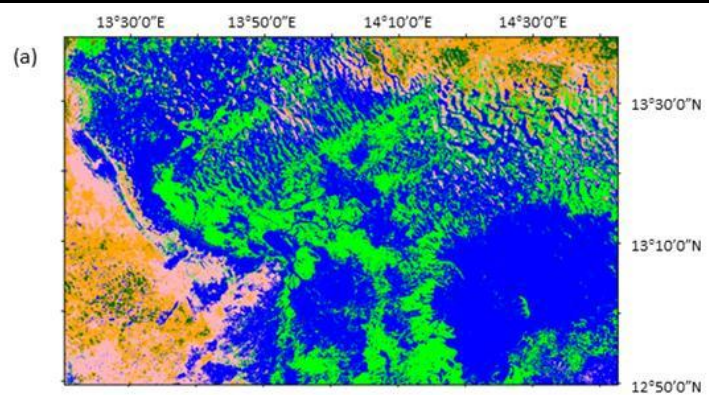


# Fire and Plume Observation and Modeling Synergy

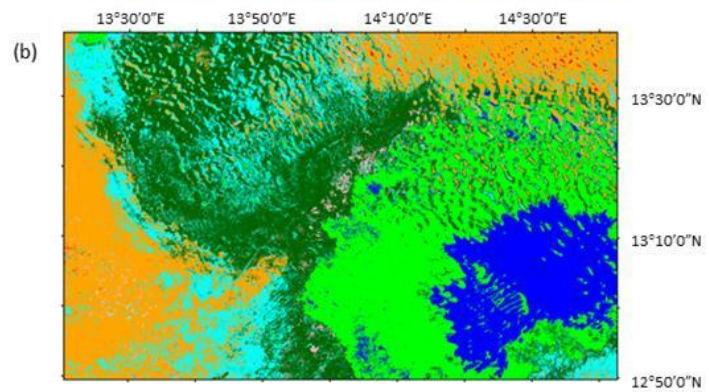


# Land cover change around Lake Chad

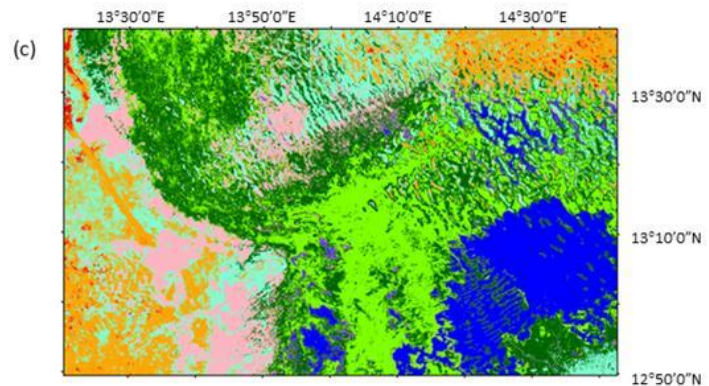
1979



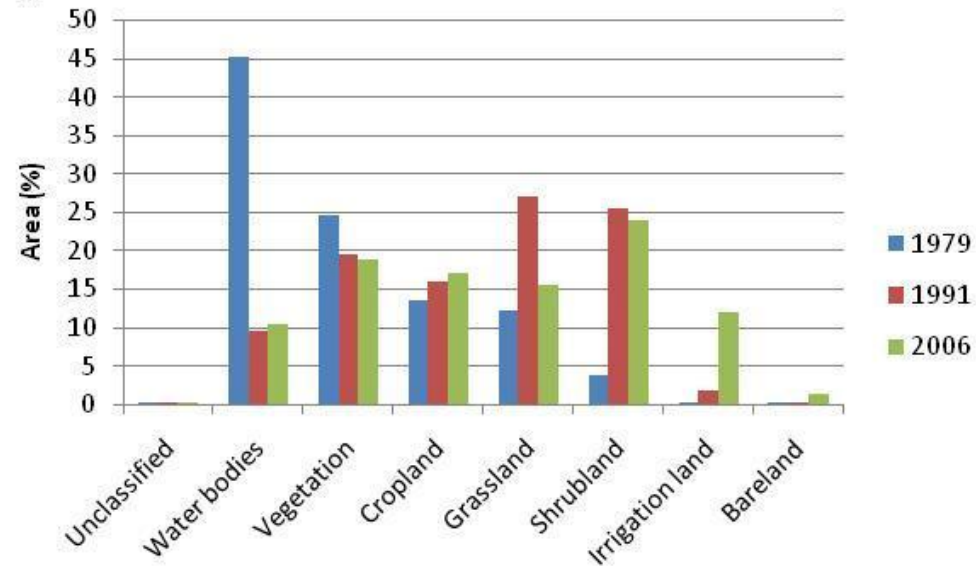
1991



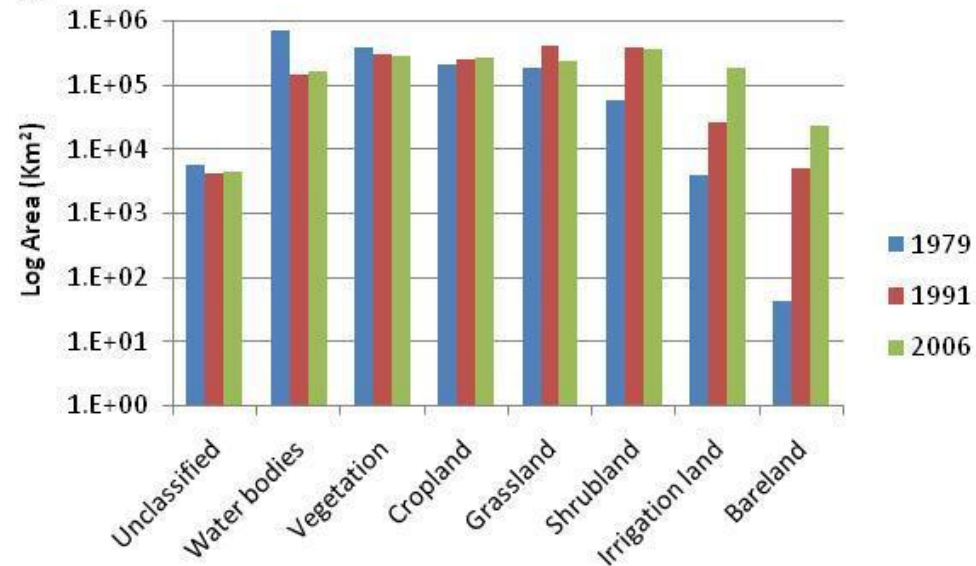
2006



(a)

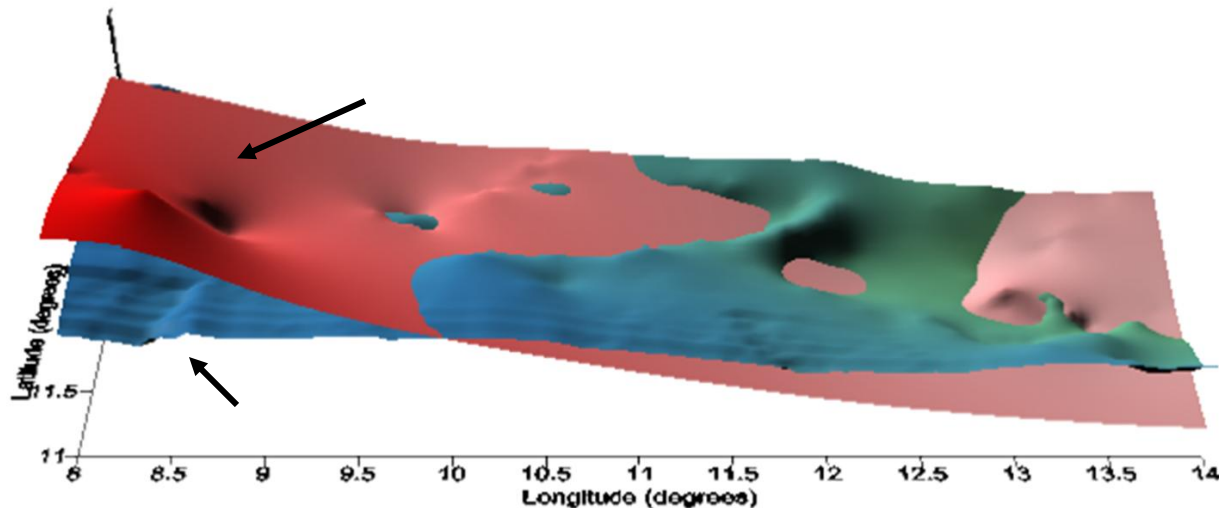
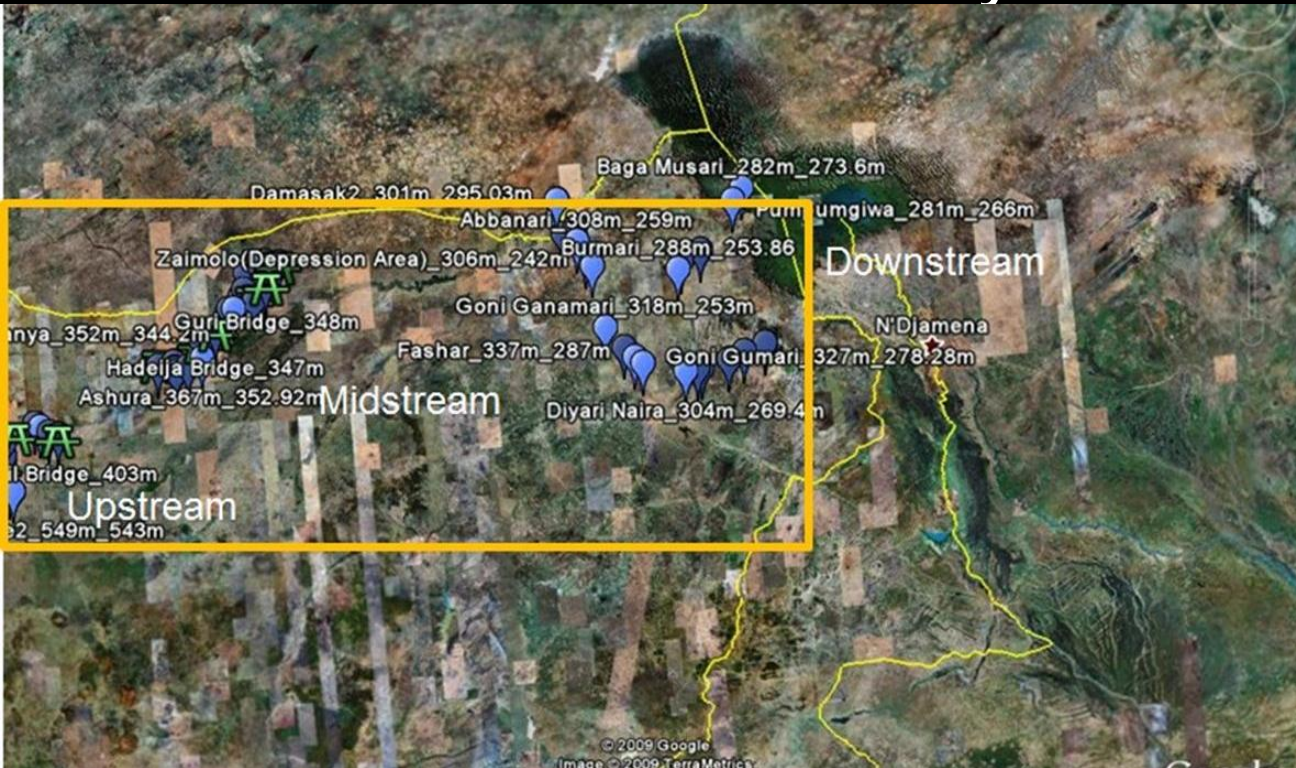


(b)





# Groundwater Field Survey in the summer of 2009



# Plans

- Continue detailed data analysis and modeling to understand the different aspects of the issue.
- Closely coordinate the different components of the study to establish linkages in a coherent manner.
- Publish results in peer-reviewed literature.
- Collaborate with and share data and knowledge with various regional and local subject matter experts.
- Provide applicable findings to relevant agencies and organizations for use in decision making.